CS4243 Project
Video Object Tracking

Team members

Manh Pham Cuong
Nguyen Dinh Truong Huy
Nguyen Thuy Dung

Lecturers

Leow Wee Kheng
Sim Mong Cheng, Terence

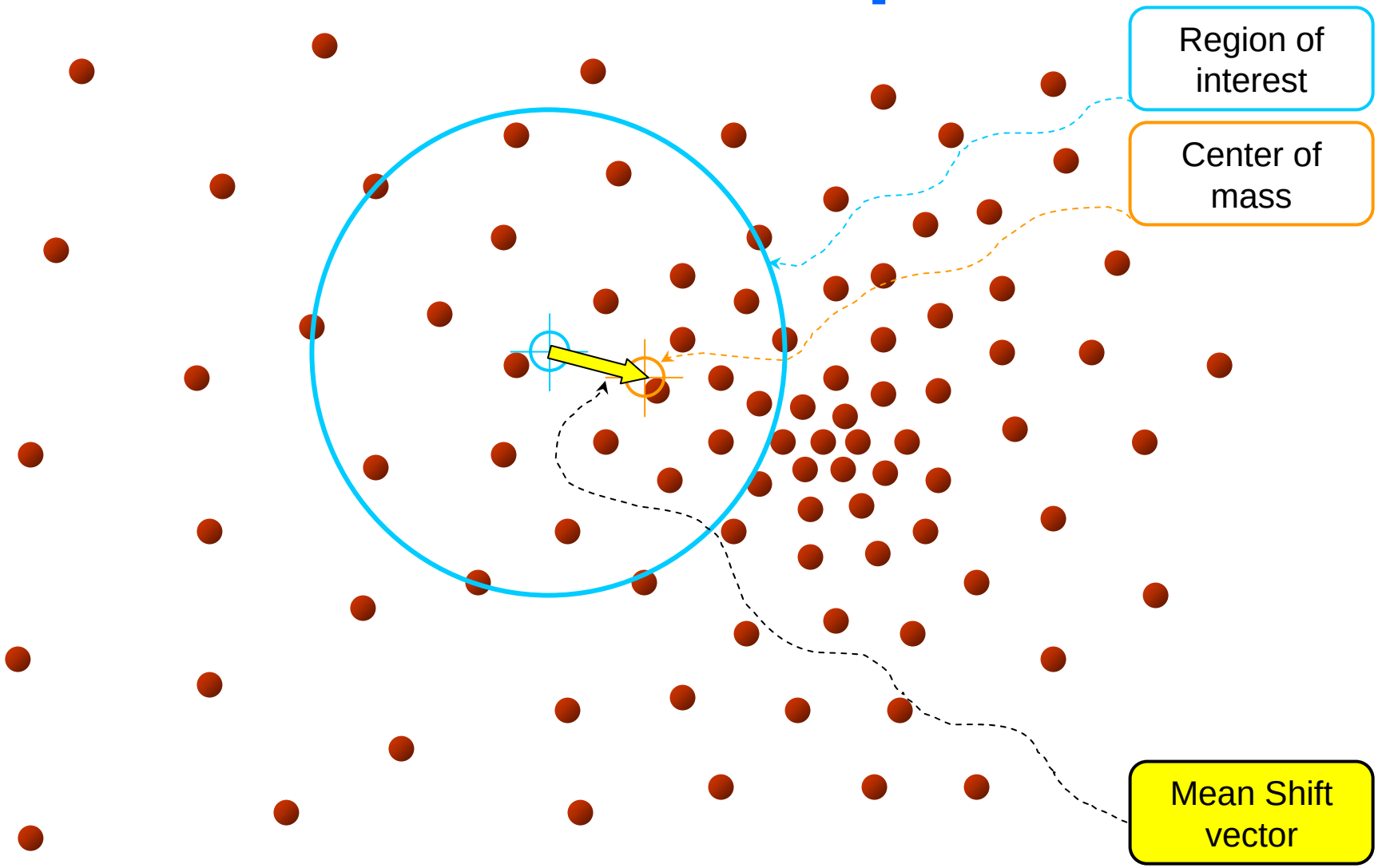
Contents

- Mean shift algorithm
- Basic feature
  - No occlusion
  - No change
- Further features:
  - Track an object that changes in size.
  - Track an object that is occluded in a number of frames
- Improvements
- References

Overall idea

- Mean shift intuition
  - **Slide credit: Yaron Ukrainitz & Bernard Sarel**

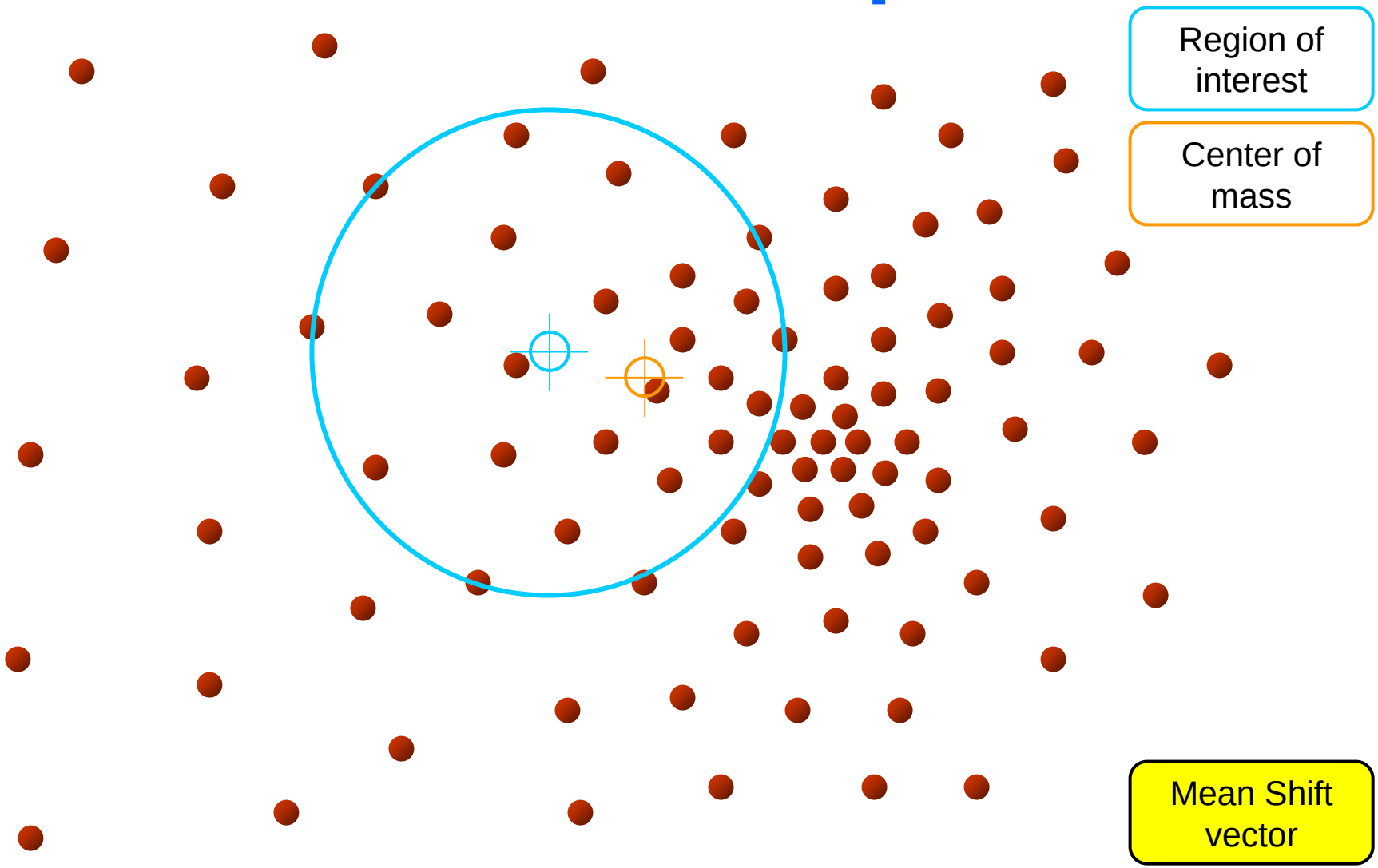
Intuitive Description



Objective : Find the densest region

Distribution of identical billiard balls

Intuitive Description



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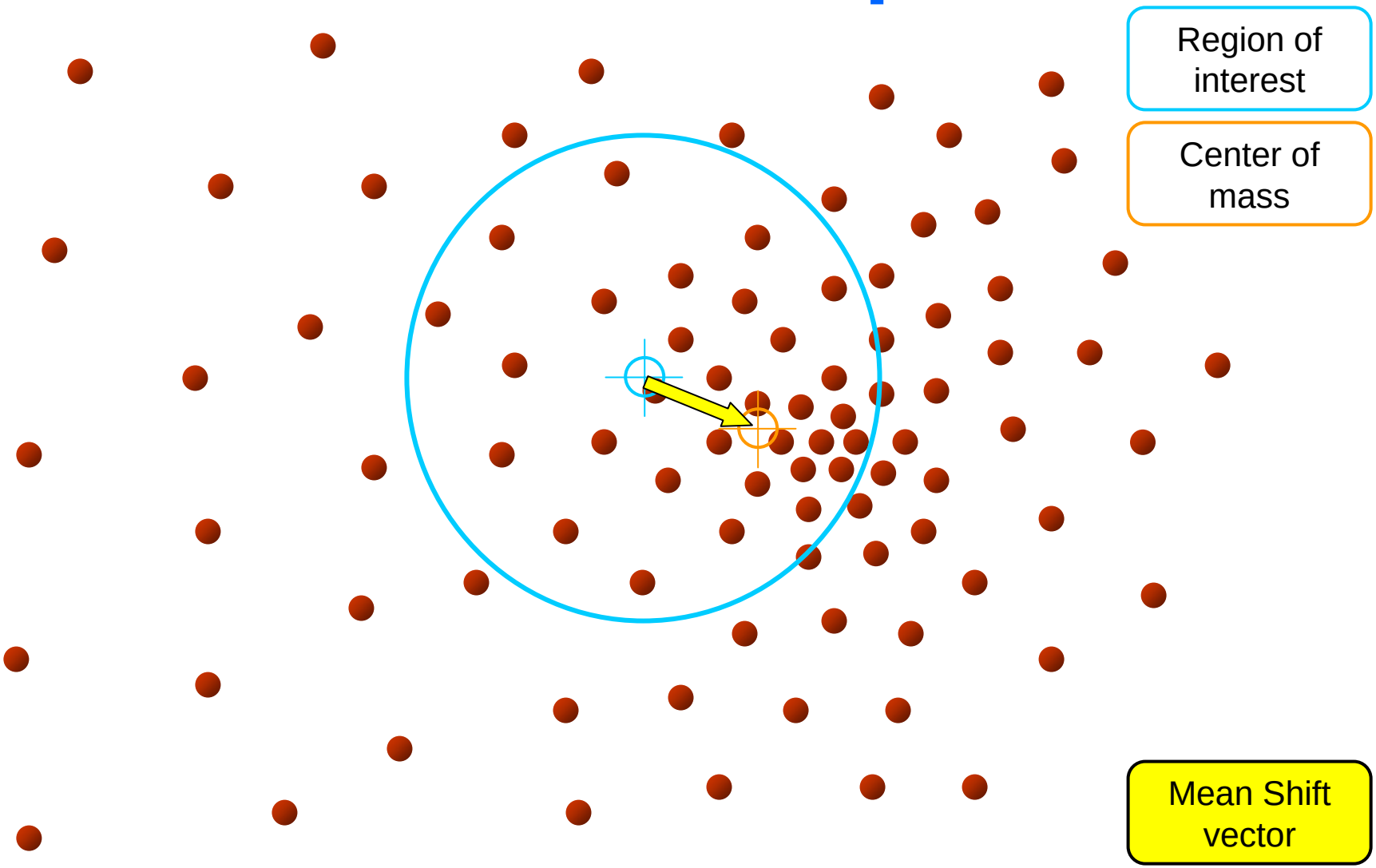

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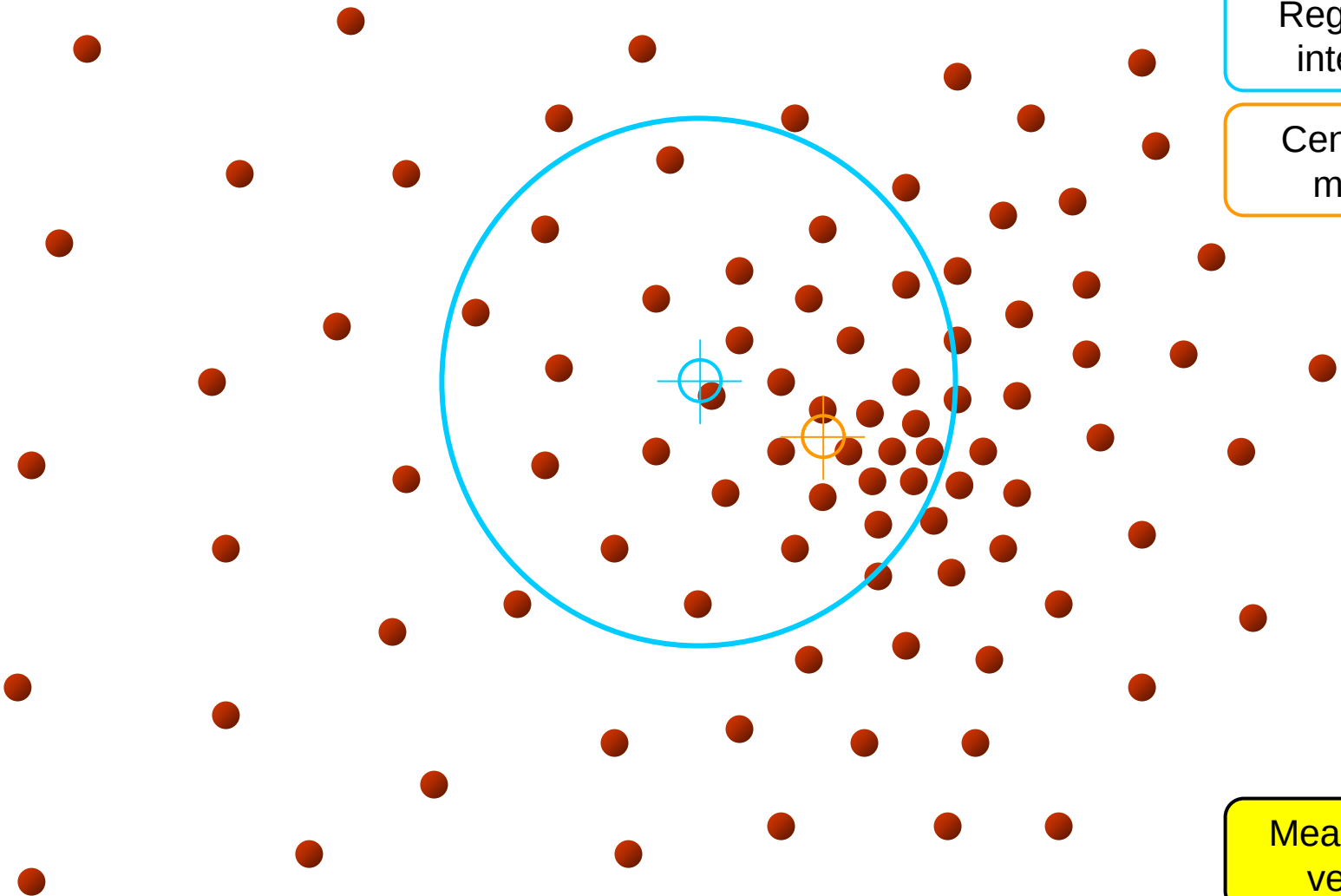

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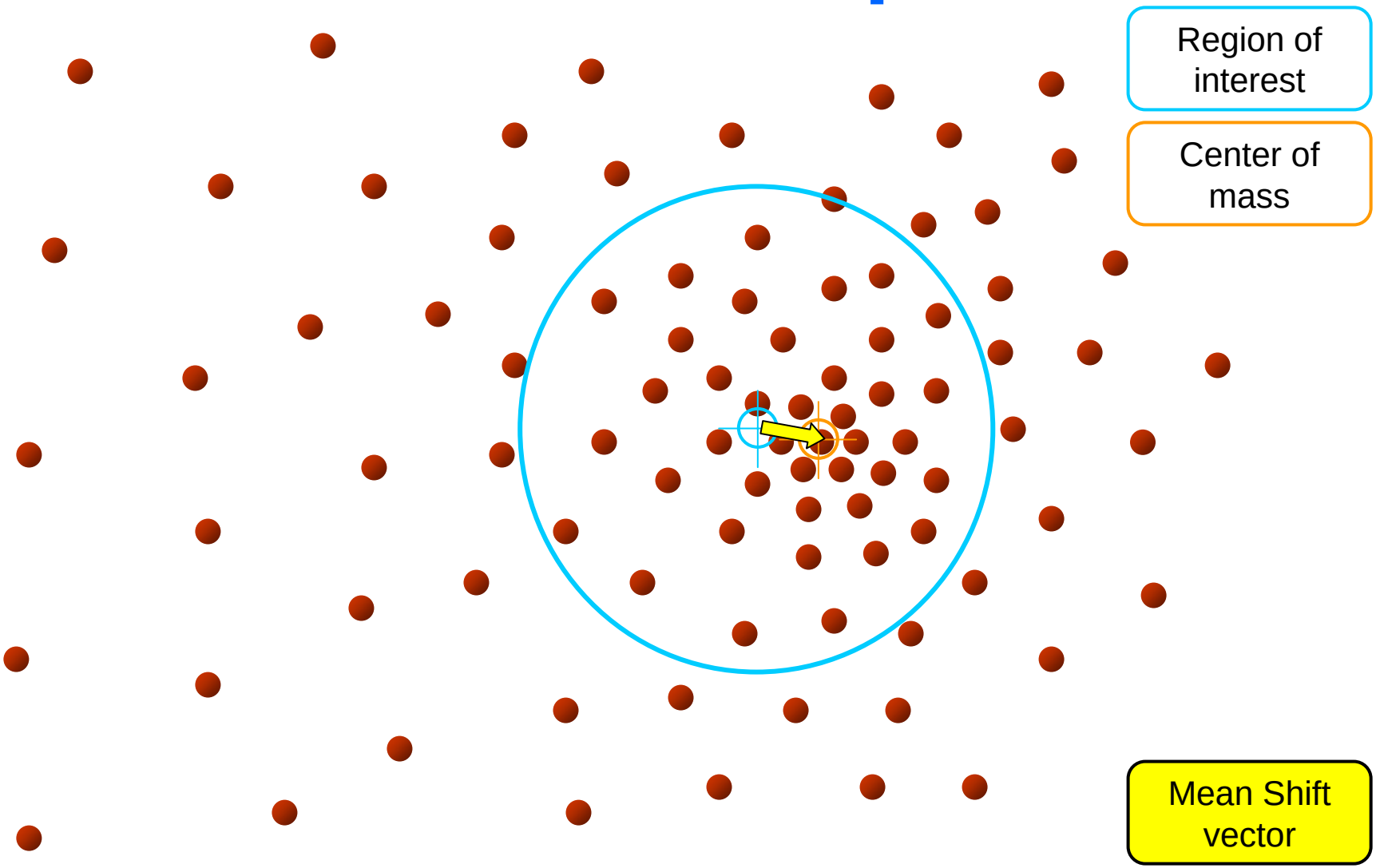

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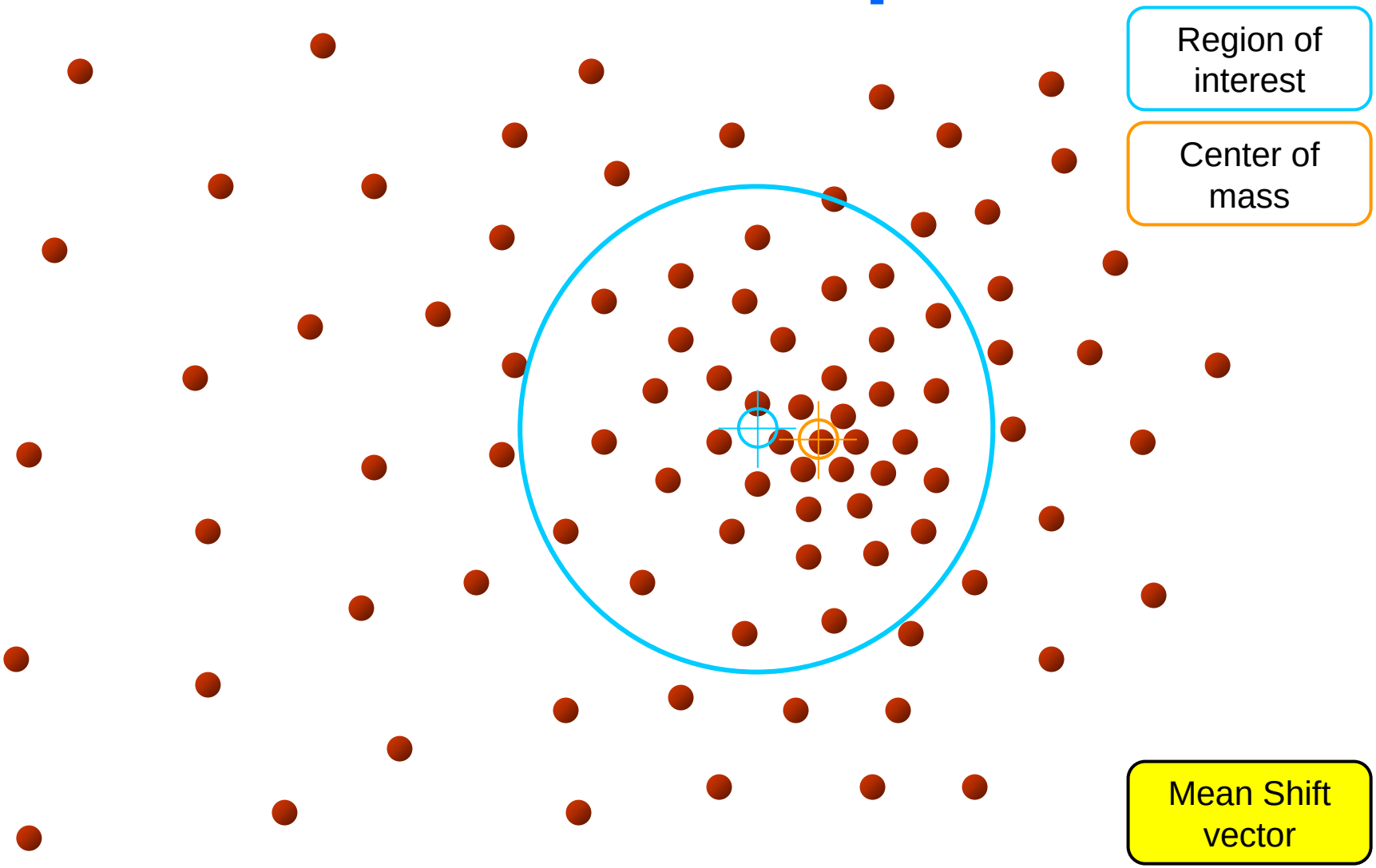

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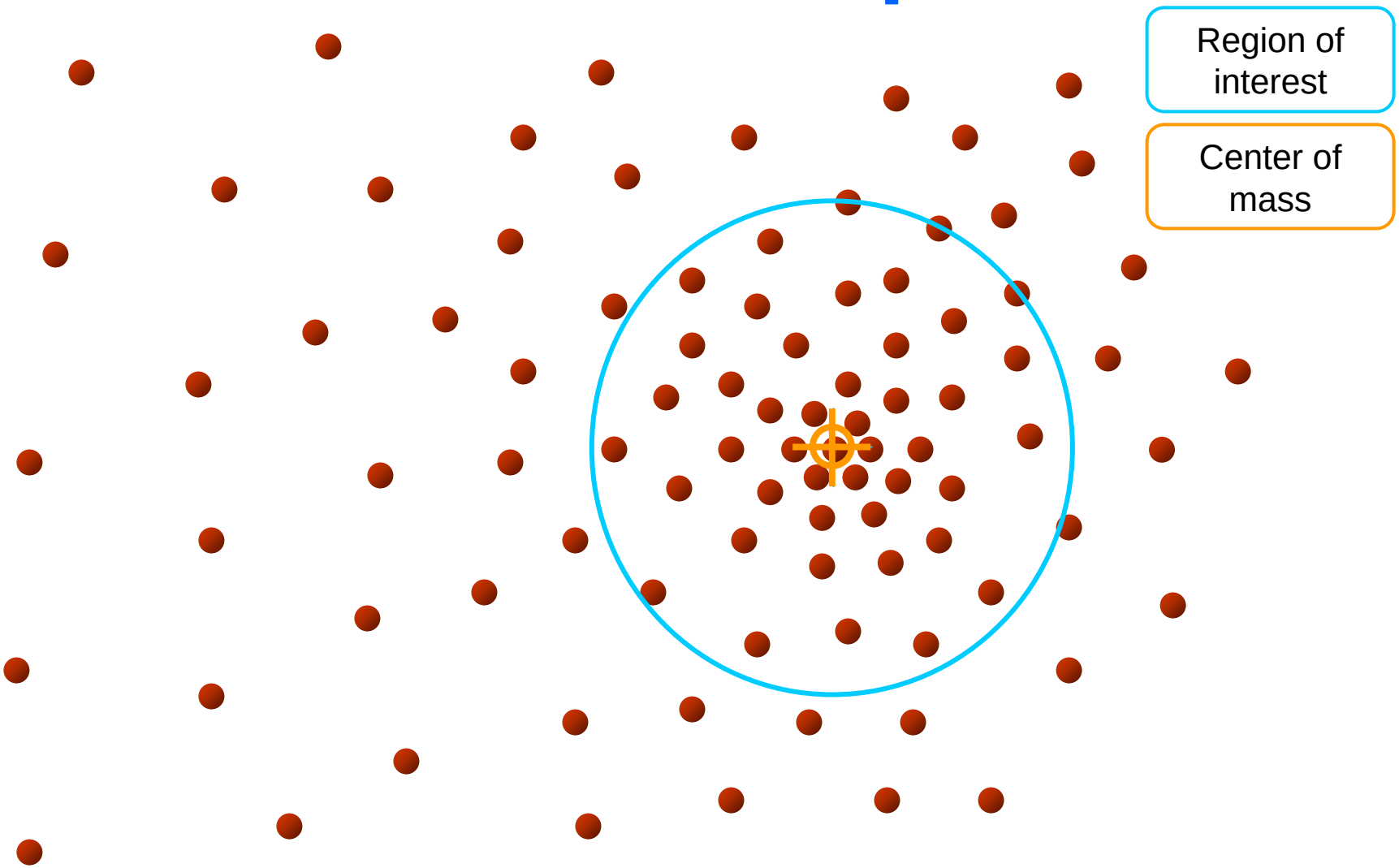

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Distribution of identical billiard balls

Color space

- HSV (Hue, Saturation, Value)
- Characteristics
  - Similar to human visual perception of color.
  - Robust with lighting changes.
  - Quantization rate
    - Hue (color): 8
    - Saturation (gray scale): 8
    - Value (color darkness): 4

Basic Level

No occlusion or size change

Basic level

- Demonstration video

Basic level

- Originally non-negative weights

$$w_i = \sum_{u=1}^{m} \delta\left[b(x_i) - u\right] \sqrt{\frac{\hat{q}_u}{\hat{p}_u(\hat{y}_0)}}$$

- Works well only when
  - The tracked object moves at low speed (background colors rarely dominate target candidate).

Basic level

- Our approach:

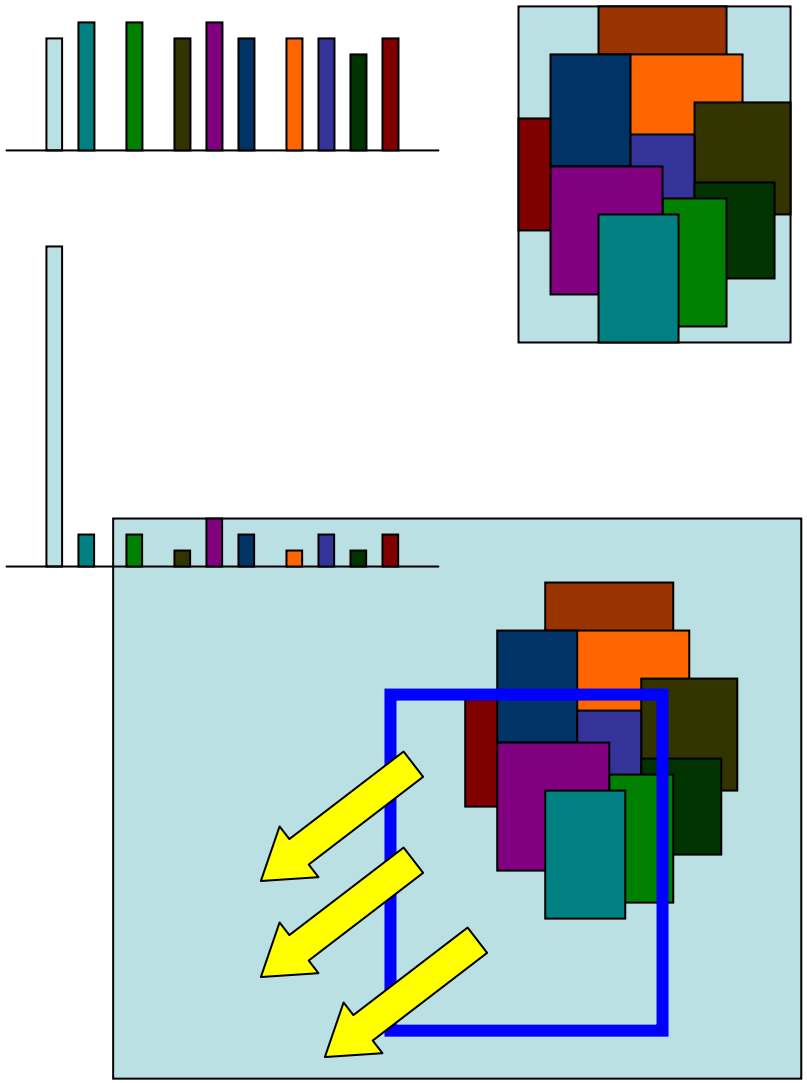
  Mean shift with negative weights allowed.

$$w_i = \sum_{u=1}^{m} \delta\left[b(x_i) - u\right] \log\left(\frac{\hat{q}_u}{\hat{p}_u(\hat{y}_0)}\right)$$

- A point's weight: a vote for the direction of the meanshift offset.

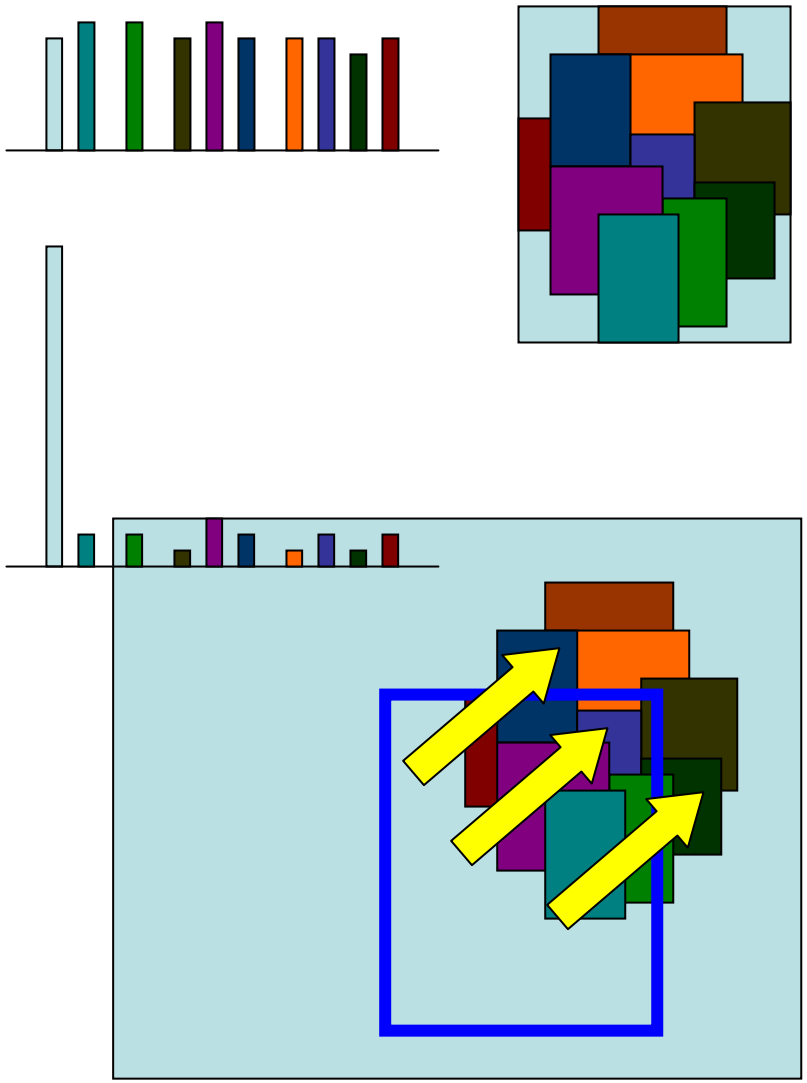
Non-negative weights

$$\sqrt{\frac{\hat{q}_u}{\hat{p}_u(\hat{y}_0)}}$$



Negative weights allowed

$$\log\left(\frac{\hat{q}_u}{\hat{p}_u(\hat{y}_0)}\right)$$



Intermediate Level

1. Change in size

Change in size

- Demonstration Video

Change in size

- Approach
  - Greedily search for the best match.
  - Vary the radius (which represents width and height)

Intermediate Level

2. Occlusion

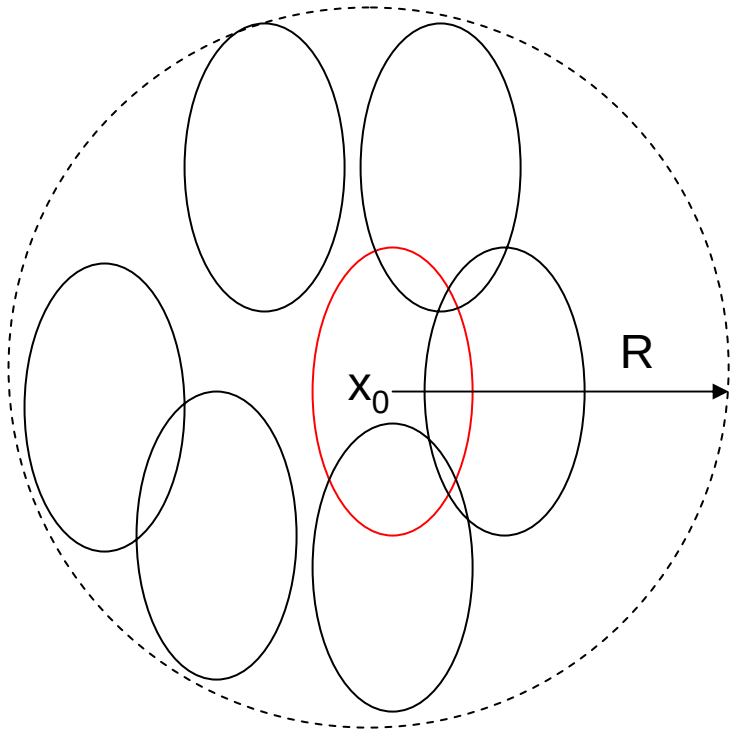
Occlusion

- Assumption during occlusion period
  - No huge change in direction and velocity.
  - No change in size.

- Terminology
  - Hypothetical states
    - Position
    - Velocity
  - Bhattacharya coefficient (Rho)
    - The similarity between the hypothetical state and the target model.
  - Mean state
    - Estimated target state
    - Mean of hypothetical states.

Approach

- Initialization
  - N hypothetical states.
  - Probability p_i for each state
    - The more similar, the more probable
- Choose hypothetical states St based on its probability
- Update hypothetical states



Approach (Occlusion)

- Occlusion detection
  - Rho of mean shift result is less than a certain threshold (empirically set)
  - Intuition
    - The object is nowhere to be found, i.e. occluded.

Approach (Occlusion)

- Occlusion period
  - Estimate the mean state
- Reoccurrence detection
  - Rho at the mean state is greater than a threshold.
  - Position of target is set to the mean state
  - Switch back to tracking using mean shift.

Occlusion

- Demonstration Video

References

[1] D. Comaniciu, V. Ramesh and P. Meer, Real-Time Tracking of Non-Rigid Objects using Mean Shift, Computer Vision and Pattern Recognition (2000) 142-149.

[2] Katja Nummiaro, et al, Color Features for Tracking Non-Rigid Objects, Chinese Journal of Automation, Vol29, No3, May 2003

[3] R. Collins, “Mean-shift blob tracking through scale space,” in Proc. IEEE Conf. on Computer Vision and Pattern Recognition, Madison,WI, 2003, pp. 234–240.